Food Chemistry, Vol. 60, No. 4, pp. 633–637, 1997

0308-8146/97 $17.00+0.00
PII: S0308-8146(97)00048-4

ELSEVIER

Effect of freezing and storage on quality factors in Hamburg and leafy parsley

Z. Lisiewska[a]* & W. Kmiecik[a]

Department of Raw Materials and Processing of Fruit and Vegetables, Agricultural University of Krakow, 3 Podluzna Street, Krakow, Poland

(Received 12 April 1996; revised version received 16 September 1996; accepted 27 January 1997)

Two types of parsley — the Hamburg cv Berlińska and leafy type cv Paramount — were frozen and stored at temperatures of −20 and −30°C for 9 months. One half of the material was blanched before freezing and the other half was non-blanched. In 100 g fresh leaves of Hamburg parsley there were 20.0 g of dry matter, 310 mg of vitamin C, 7.5 mg of β-carotene, 203 mg of chlorophyll, 30.8 mg $N\text{-}NO_3$ and 0.078 mg $N\text{-}NO_2$. For the leafy type the corresponding values were 17.3 g, 257 mg, 9.4 mg, 68.5 mg, and 0.077 mg. The material blanched before freezing showed significant losses in the contents of vitamin C (47–51%), nitrates (22–33%), and nitrites (43–55%) and distinctly smaller ones but also significant in the case of dry matter. During freezing and storage of frozen products there were losses in vitamin C, β-carotene, and chlorophyll while the levels of nitrates and nitrites were variable. Particularly great losses of vitamin C and β-carotene were observed in the non-blanched frozen leaves stored at −20°C. After 9 months' storage, frozen products preserved 10–44% of vitamin C, 37–91% of β-carotene, 78–95% of chlorophyll, and 78–153% of nitrates. Of the types of parsley analyzed the Hamburg type was a better raw material for freezing because of a significantly higher content of vitamin C and chlorophyll and significantly less nitrates in frozen products. When the storage temperature was −30°C, the blanching of leaves was not necessary, although it helped their pressing into cubes. © 1997 Elsevier Science Ltd

INTRODUCTION

Owing to their biological properties parsley leaves are among the most valuable vegetables. They are a very rich source of vitamin C, β-carotene, and mineral constituents (Bąkowski & Michalik, 1986; Michalik & Dobrzański, 1987; Wills *et al.*, 1986). A negative trait of parsley leaves, as of all leafy vegetables, is a tendency to accumulate nitrates (Fukruni & Humeid, 1988; Nabrzyski & Gajewska, 1994). The level of nitrates in the leaves may be controlled not only by applying appropriate fertilizer but also by selecting an appropriate type of parsley. The leaves of Hamburg parsley, grown on a wide scale for their roots in Central and Eastern Europe, are characterized by a higher content of vitamin C and more intensive coloration than the leafy type. However, in analogous growing conditions they accumulate distinctly less nitrate (Kmiecik *et al.*, 1995).

Parsley is an excellent raw material for drying (Bąkowski & Michalik, 1986; Nutting *et al.*, 1970) but the dry leaves have to be rehydrated before use and may not be suitable for all dishes. The freezing of parsley leaves, particularly as pressed cubes, ensures their easy, rapid, and wide application in the home and in restaurants.

The aim of the work was to determine the effect of the type of parsley, the character of preliminary processing, temperature of freezing, and period of storage on the quality of frozen parsley leaves. The criterion of quality evaluation was the level of selected physico-chemical indices.

MATERIALS AND METHODS

Materials

Two types of parsley — the Hamburg cv Berlińska and leafy type cv Paramount — were investigated. The vegetable was harvested in the experimental field of the Department, in southern Poland (Krakow region). The cultivation was carried out on loamy and silty soil in the second year after manuring (30 t ha^{-1}). Mineral fertilizer was adjusted to the soil fertility and nutritional requirement of the plants. The level of fertilizer was 80 kg ha^{-1}

*To whom correspondence should be addressed.

before the first harvest and 40 kg after each leaf cutting, P_2O_5 80 kg ha^{-1} and K_2O 150 kg ha^{-1}.

Leaves for freezing were taken from the first harvest, carried out after they had fully developed, i.e., early in July (about 3 months after sowing). The technological process of freezing consisted of sorting, washing, cutting off petioles to preserve the leaf blades only, in some cases blanching in water at 96–98°C for 1 min (at a leaf: water ratio of 1:5), cooling for 2 min, centrifuging to remove the water, cutting leaves into 0.5 cm pieces, pressing into cubes of 18×14×2 cm and freezing. The time from harvest to freezing did not exceed 3–4 h. Samples were blast-frozen in a climatic Feutron 3101-01 chamber at −35°C. The product was frozen to storage temperatures of −20°C and −30°C and remained in cold rooms until the time of evaluation.

Methods

The levels of the following indices were determined in the raw material, in the leaves after blanching, and in the frozen leaves directly after freezing and after 3, 6 and 9 months of storage, using methods given in the literature: dry weight (AOAC 1984), L-ascorbic acid (ISO/6557-2), vitamin C (total of ascorbic and dehydroascorbic acids) by reducing dehydroascorbic to ascorbic acid with hydrogen sulphide and determining their total content as ascorbic acid (ISO/6557-2), β-carotene (ISO/6558-2), chlorophyll according to the method given by Wettstein (1957), and nitrates and nitrites (ISO/6635).

Analyses of the content of each component were carried out in four replications (in two parallel samples) taken from four plots (of 2 m^2 each) from a field of 300 m^2. In order to reveal possible differences in the levels of the indices investigated Snedecor's F test and Student's t-test were used in the statistical analysis and the least significant difference (LSD) was computed at a probability level of $P = 0.05$.

RESULTS AND DISCUSSION

In the two types of fresh parsley leaves tested, the contents of the analyzed components (Tables 1–6) were within the values given in the literature (Bąkowski & Michalik, 1986; Michalik & Dobrzański, 1987; Nabrzyski & Gajewska, 1994; Wills *et al.*, 1986; Yamauchi & Watata, 1993).

The leaves of the Hamburg parsley, compared with those of the leafy type, contained significantly less nitrate but more dry matter, vitamin C, and chlorophyll.

After blanching, the content of dry matter was reduced significantly in both types of parsley, by around 16% (Table 1). The freezing process raised the level of dry weight by around 2–4% in comparison with the content before this treatment. During the storage of frozen leaves, no significant changes in the level of this index were observed. After 9 months' storage the frozen products contained more dry weight in the Hamburg parsley and samples of the non-blanched material.

Blanching significantly reduced the content of vitamin C (47–51%), greater losses being found in the leafy type parsley (Table 2). Significant losses in vitamin C content due to blanching of the parsley leaves may be considered as normal. Okeibuno-Badifu (1991) observed 47–58% losses of this vitamin while blanching three species of leafy vegetables. Directly after freezing non-blanched leaves, both types of parsley contained significantly more vitamin C than the blanched ones. During storage the level of vitamin C in the frozen products gradually fell. However, the percentage losses were distinctly greater if the raw material used for freezing was not blanched. The losses were additionally increased at the higher storage temperature.

After 9 months' storage, the content of vitamin C in 100 g of the product varied from 24 to 136 mg; this constituted 10–44% of the amount found in the raw material. After this period the vitamin C content in the leaves of the Hamburg parsley was 38% greater than that in the leafy type, 37% greater in blanched leaves than in non-blanched ones and 238% greater in leaves stored at −30°C than in those kept at −20°C in non-blanched material and 24% in blanched products. It should, however, be stressed that the shorter the storage period, the smaller were the differences. Jurics (1970), in a study on vitamin C content in blanched vegetables stored at temperatures varying from −18 to −28°C, found that, with the lower storage temperature the preservability of this vitamin was 9–11% higher, depending on the species. Also it should be stressed that the proportion of L-ascorbic acid in vitamin C was rapidly reduced in leaves stored at higher temperatures, especially if no blanching was applied. After 9 months' storage this proportion in non-blanched samples reached about 10% at −20°C and 30% at −30°C, while in blanched leaves it varied from 70 to 98%, depending on the sample.

Blanching did not significantly reduce the level of β-carotene in the leaves of the two types of parsley (Table 3). Nutting *et al.* (1970) recorded a higher content of this component in parsley after blanching than in the raw material. According to Nutting *et al.* (1970), blanching prevented any significant losses of β-carotene, both in the process of freezing and in the further storage of the frozen product. In the work discussed the freezing of non-blanched leaves caused significant losses of β-carotene which were not significant if blanching was applied. During 9 months storage of blanched leaves, β-carotene losses reached 4% in the Hamburg parsley and 22% in the leafy type, with no significant difference between the storage temperatures. In the non-blanched material stored at −30°C, total losses reached 5–11%. At −20°C the level of losses during the storage period alone ranged from 29% in the Hamburg parsley to 49%

Table 1. Content of dry matter[a] in fresh and frozen parsley leaves (%)

Type of parsley	Preparation method	Before freezing	Storage temperature	After freezing and storage time in months				LSD $P=0.05$
				0	3	6	9	
Hamburg parsley	Non-blanched	20.0	−20°C	20.4	20.4	20.4	20.3	$F_{emp} < F_t$
		20.0	−30°C	20.5	20.5	20.5	20.4	$F_{emp} < F_t$
	Blanched	16.8	−20°C	17.1	17.2	17.0	16.9	$F_{emp} < F_t$
		16.8	−30°C	17.2	17.2	17.1	16.9	$F_{emp} < F_t$
Leafy parsley	Non blanched	17.3	−20°C	18.0	18.3	18.3	18.3	$F_{emp} < F_t$
		17.3	−30°C	18.2	18.1	18.3	18.2	$F_{emp} < F_t$
	Blanched	14.6	−20°C	15.0	15.1	15.0	15.1	$F_{emp} < F_t$
		14.6	−30°C	15.3	15.3	15.3	15.2	$F_{emp} < F_t$
LSD $P=0.05$		1.25		0.87	0.81	0.90	0.92	

[a]From four determinations

Table 2. Content of vitamin C[a] in fresh and frozen parsley leaves, in mg/100 g

Type of parsley	Preparation method	Before freezing	Storage temperature	After freezing and storage time in months				LSD $P=0.05$
				0	3	6	9	
Hamburg parsley	Non-blanched	310	−20°C	263	93	69	44	18.2
		310	−30°C	252	181	145	136	18.9
	Blanched	164	−20°C	162	135	114	104	12.0
		164	−30°C	160	149	129	125	14.2
Leafy parsley	Non-blanched	257	−20°C	166	95	39	24	13.3
		257	−30°C	159	145	123	94	14.1
	Blanched	125	−20°C	122	102	84	78	8.5
		125	−30°C	120	115	111	101	9.0
LSD $P=0.05$		20.9		12.0	13.2	9.5	8.1	

[a]From four determinations.

Table 3. Content of β-carotene[a] in fresh and frozen parsley leaves, in mg/100 g

Type of parsley	Preparation Method	Before freezing	Storage temperature	After freezing and storage time in months				LSD $P=0.05$
				0	3	6	9	
Hamburg parsley	Non-blanched	7.5	−20°C	6.8	4.9	4.9	4.8	0.56
		7.5	−30°C	6.7	6.6	6.5	6.4	0.47
	Blanched	7.0	−20°C	7.0	6.8	6.7	6.7	$F_{emp} < F_t$
		7.0	−30°C	7.0	7.0	6.8	6.8	$F_{emp} < F_t$
Leafy parsley	Non-blanched	9.4	−20°C	6.9	3.6	3.5	3.5	0.43
		9.4	−30°C	6.8	6.7	6.6	6.5	0.36
	Blanched	8.7	−20°C	8.6	7.1	6.8	6.7	0.60
		8.7	−30°C	8.5	7.4	7.0	6.8	0.66
LSD $P=0.05$		$F_{emp} < F_t$		0.56	0.44	0.42	0.45	

[a]From four determinations.

in the leafy type, most losses occurring during the first 3 months of storage.

After 9 months' storage of frozen parsley leaves, the preservability of β-carotene was 37–91% of the content in the raw material. The percentage losses of β-carotene were distinctly smaller in the Hamburg parsley than in the leafy type leaves. In both types the losses were significantly greater in non-blanched leaves stored at higher temperatures. Chladek (1972) observed that, after 21 days' storage, the losses of β-carotene in frozen non-blanched dill twice exceeded those in blanched material. Preservability in non-blanched frozen dill reached 58% after a storage period of 7 months.

The decisive factor influencing the color of frozen parsley leaves is their chlorophyll content. According to Sweeney and Martin (1961), the destruction of chlorophyll is predominantly responsible for the deterioration of color. The losses of chlorophyll on blanching were not significant (Table 4). For chlorophyll b, the losses were twice as high as those of chlorophyll a. During

Table 4. Content of chlorophyll[a] in fresh and frozen parsley leaves, in mg/100 g

Type of parsley	Preparation Method	Before freezing	Storage temperature	After freezing and storage time in months				LSD $P=0.05$
				0	3	6	9	
Hamburg parsley	Non-blanched	203	−20°C	197	196	196	190	$F_{emp} < F_t$
		203	−30°C	197	198	192	192	$F_{emp} < F_t$
	Blanched	189	−20°C	186	182	181	180	$F_{emp} < F_t$
		189	−30°C	184	181	180	181	$F_{emp} < F_t$
Leafy parsley	Non-blanched	182	−20°C	172	162	155	142	10.3
		182	−30°C	170	165	160	162	12.1
	Blanched	166	−20°C	162	160	156	149	9.2
		166	−30°C	160	162	158	160	$F_{emp} < F_t$
LSD $P=0.05$		16.1		12.4	10.8	11.5	11.7	

[a]From four determinations.

Table 5. Content of nitrates[a] in fresh and frozen parsley leaves, in mg/1000 g

Type of parsley	Preparation Method	Before freezing	Storage temperature	After freezing and storage time in months				LSD $P=0.05$
				0	3	6	9	
Hamburg parsley	Non-blanched	308	−20°C	394	399	359	316	24.8
		308	−30°C	405	424	415	335	26.2
	Blanched	207	−20°C	268	299	232	241	22.5
		207	−30°C	273	297	262	257	21.7
Leafy parsley	Non-blanched	685	−20°C	913	1129	1080	979	41.5
		685	−30°C	918	1226	1200	1050	56.6
	Blanched	537	−20°C	566	857	849	832	43.1
		537	−30°C	571	902	868	821	34.9
LSD $P=0.05$		30.7		30.5	57.3	46.9	41.2	

[a]From four determinations.

Table 6. Content of nitrites[a] in fresh and frozen parsley leaves, in mg/1000 g

Type of parsley	Preparation Method	Before freezing	Storage temperature	After freezing and storage time in months				LSD $P=0.05$
				0	3	6	9	
Hamburg parsley	Non-blanched	0.78	−20°C	0.65	0.78	0.94	0.98	0.151
		0.78	−30°C	0.70	0.68	0.52	0.57	0.147
	Blanched	0.35	−20°C	0.32	0.50	0.65	0.83	0.138
		0.35	−30°C	0.33	0.45	0.46	0.41	0.084
Leafy parsley	Non-blanched	0.77	−20°C	0.69	0.46	0.53	0.88	0.153
		0.77	−30°C	0.71	0.47	0.47	0.49	0.138
	Blanched	0.44	−20°C	0.42	0.35	0.37	0.78	0.125
		0.44	−30°C	0.39	0.25	0.18	0.18	0.100
LSD $P=0.05$		0.172		0.136	0.122	0.107	0.101	

[a]From four determinations.

freezing, chlorophyll losses were not significant. In the storage period, the level of chlorophyll was not significantly reduced in frozen products, except for leafy type parsley leaves, non-blanched and blanched and stored at −20°C.

After 9-months' storage the losses reached 5–22% in relation to the raw material. Chlorophyll content was significantly higher in leaves of the Hamburg parsley than in those of the leaf type. In both types of parsley, no significant differences were found between the blanched and non-blanched products stored at the same temperature. In leafy non-blanched parsley, significant differences were noted in favor of samples stored at −30°C. Similar results were obtained by Philippon *et al.* (1986) who stored parsley at −20°C and −65°C.

Nitrates, which are natural components of vegetable raw materials, are usually regarded as undesirable constituents, since they may be reduced to toxic nitrites. Changes in the level of these compounds during the technological processing and storage of frozen products are shown in Tables 5 and 6. Blanching significantly depressed the contents of both forms of nitrogen. In the case of nitrates, the reduction reached 22–33% and in the case of nitrites 43–55%, with greater percentage losses in the leaves of the Hamburg parsley. The above observation approximates to the results obtained by Niedzielski and Mokrosińska (1982), and Sistrunk and Cash (1975) in studies concerning the effect of this treatment on the behavior of nitrates and nitrites in Brussels sprouts and spinach.

During freezing, the level of nitrates rose significantly except for the leafy blanched samples, and that of nitrites fell but not significantly. During the storage of frozen products the contents of nitrates varied to a certain degree, though the effect of storage temperatures on their levels was not uniform. In general, the content of nitrites significantly rose at higher storage temperatures and (not significantly) fell at lower ones, particularly for the leaf type parsley.

After 9 months' storage, frozen parsley leaves contained 78–153% nitrates and 23–136 % nitrites in relation to the raw material. In general, leaves of the leafy type parsley contained significantly more nitrates and not significantly less nitrites than the Hamburg type. The contents of the two compounds were lower, but not always significantly so, in samples of the blanched material. The results shown here also confirm the opinion of Sung *et al.* (1991) that ascorbic acid in some measure inhibits the formation of nitrites, since in samples with its higher content the amounts of these compounds were usually smaller.

CONCLUSIONS

The freezing of parsley leaves as pressed cubes is an appropriate method for their conservation, ensuring satisfactory preservability of vitamin C and β-carotene. If a cold store with a storage temperature of about $-30°C$ is available, the blanching treatment may be omitted. In the case of higher storage temperatures, blanching is essential. Moreover, it aids the formation of cubes. Of the types of parsley analyzed, the leaves of the Hamburg parsley are the better raw materials for freezing because of their significantly higher vitamin C and chlorophyll content and significantly lower nitrate content.

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